Climate Change Summary, Cumberland Gap National Historical Park, USA

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Climate Trends for the Area within Park Boundaries

- Average annual temperature decreased slightly in the period 1950-2010, but the rate was not statistically significant (Table 1, Figure 2). While average annual temperatures have increased across most of the world, the southeastern U.S. is an anomaly due to El Niño and other factors (Portmann et al. 2009).
- In the park, summer (June-August) average temperature increased at a rate of 0.5 ± 0.6ºC per century (0.9 ± 1.1ºF. per century) in the period 1950-2010. The rate was not statistically significant.
- Average total precipitation decreased in the period 1950-2010, but the rate was not statistically significant (Table 1, Figure 2). Precipitation decreased in winter (December-February) but increased in spring, summer, and fall. The rates were not statistically significant.
- If the world does not reduce emissions from power plants, cars, and deforestation by 40-70%, models project substantial warming and increases in precipitation (Table 1, Figure 3).
- Under the highest emissions scenario, models project 15-20 more days per year with a maximum temperature >35ºC (95ºF.) by 2100 and an increase in 20-year storms (a storm with more precipitation than any other storm in 20 years) to once every 5 years (Walsh et al. 2014).

Published Historical Impact in the Region

- Analyses of Audubon Christmas Bird Count data across the United States, including counts in the region, detected a northward shift of winter ranges of a set of 254 bird species at an average rate of 0.5 ± 0.3 km per year from 1975 to 2004, attributable to human climate change and not other factors (La Sorte and Thompson 2007).

Published Future Vulnerabilities in the Region

- Under high emissions, the region could become more favorable to the growth of the invasive plants kudzu (*Pueraria lobata*) and privet (*Ligustrum sinense*) (Bradley et al. 2010).
- Experimental increases of atmospheric carbon dioxide in a North Carolina forest indicate that climate change could increase the growth and toxicity of poison ivy (Mohan et al. 2006).
- Under the highest emissions scenario, climate change could shift the ranges of numerous tree species northward, reducing potential densities of red maple (Iverson et al. 2008).

- Under continued climate change, longer growing seasons may increase the risk of southern pine beetle outbreaks and expand the range of the beetle northward, increasing forest mortality (McNulty et al. 2013)
- Under continued climate change, increasing winter temperatures may exacerbate hemlock woolly adelgid infestation and increase mortality of hemlock trees (Dukes et al. 2009).
- Under high emissions, hotter temperatures may shift the range for the endangered Indiana Bat northward away from the park due to a loss of suitable summer climate for maternity colonies (Loeb and Winters 2013).

Table 1. Historical rates of change per century and projected future changes in annual average temperature and annual total precipitation (data Daly et al. 2008, IPCC 2013; analysis Wang et al. in preparation). The table gives the historical rate of change per century calculated from data for the period 1950-2013. Because a rate of change per century is given, the absolute change for the 1950-2013 period will be approximately 60% of that rate. The table gives central values for the park as a whole. Figures 1-3 show the uncertainties.

	1950-2013	2000-2050	2000-2100
Historical			
temperature	-0.3ºC/century (-0.5ºF./century)		
precipitation	-3%/century		
Projected (compared to 1971-2000)			
Low emissions (IPCC RCP 4.5)			
temperature		+2.1ºC (+3.8ºF.)	+2.7ºC (+4.9ºF.)
precipitation		+5%	+6%
High emissions (IPCC RCP 6.0)			
temperature		+1.7ºC (+3.1ºF.)	+3.1ºC (+5.6ºF.)
precipitation		+5%	+7%
Highest emissions (IPCC RCP 8.5)			
temperature		+2.6ºC (+4.7ºF.)	+4.7ºC (+8.5ºF.)
precipitation		+6%	+10%

Figure 1. Historical annual average temperature for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

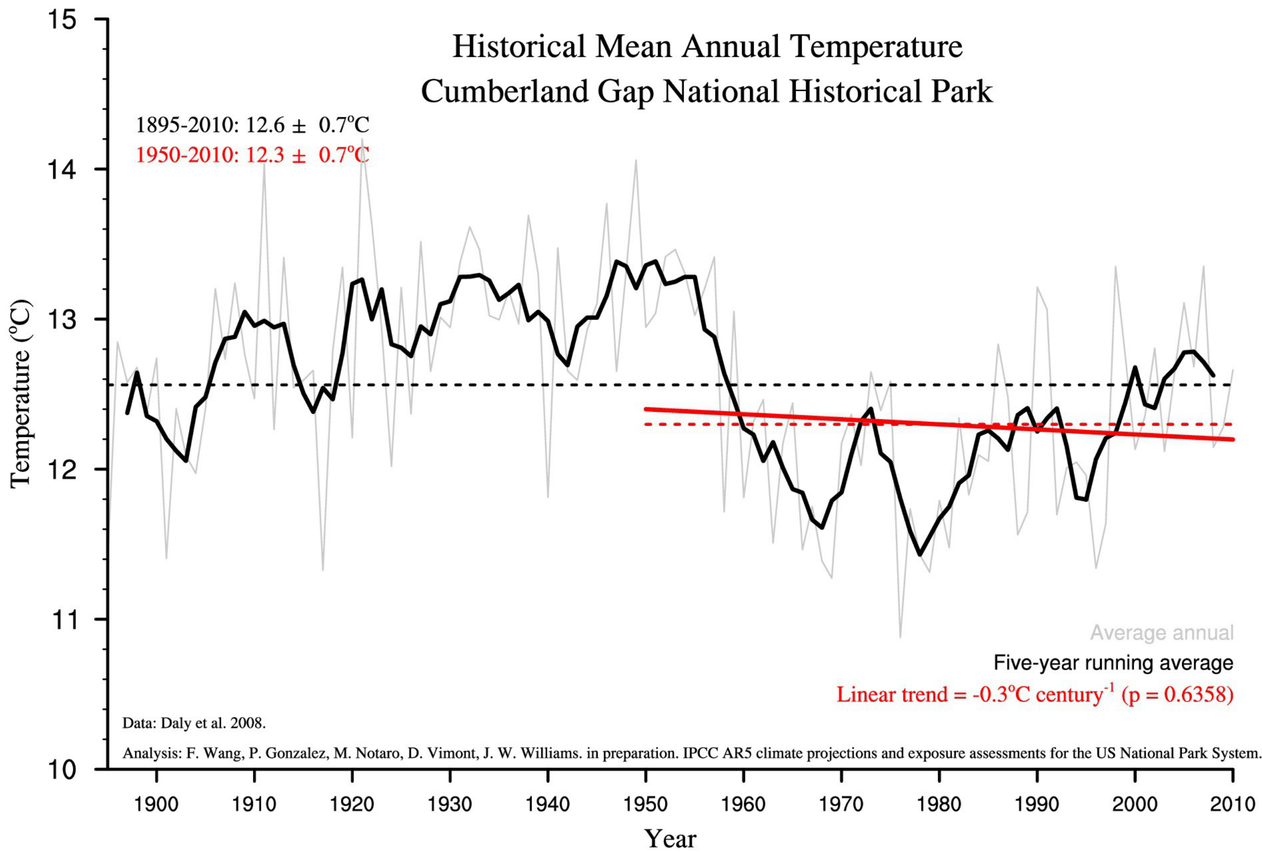


Figure 2. Historical annual total precipitation for the area within park boundaries. Note that the U.S. weather station network was more stable for the period starting 1950 than for the period starting 1895. (Data: National Oceanic and Atmospheric Administration, Daly et al. 2008. Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).

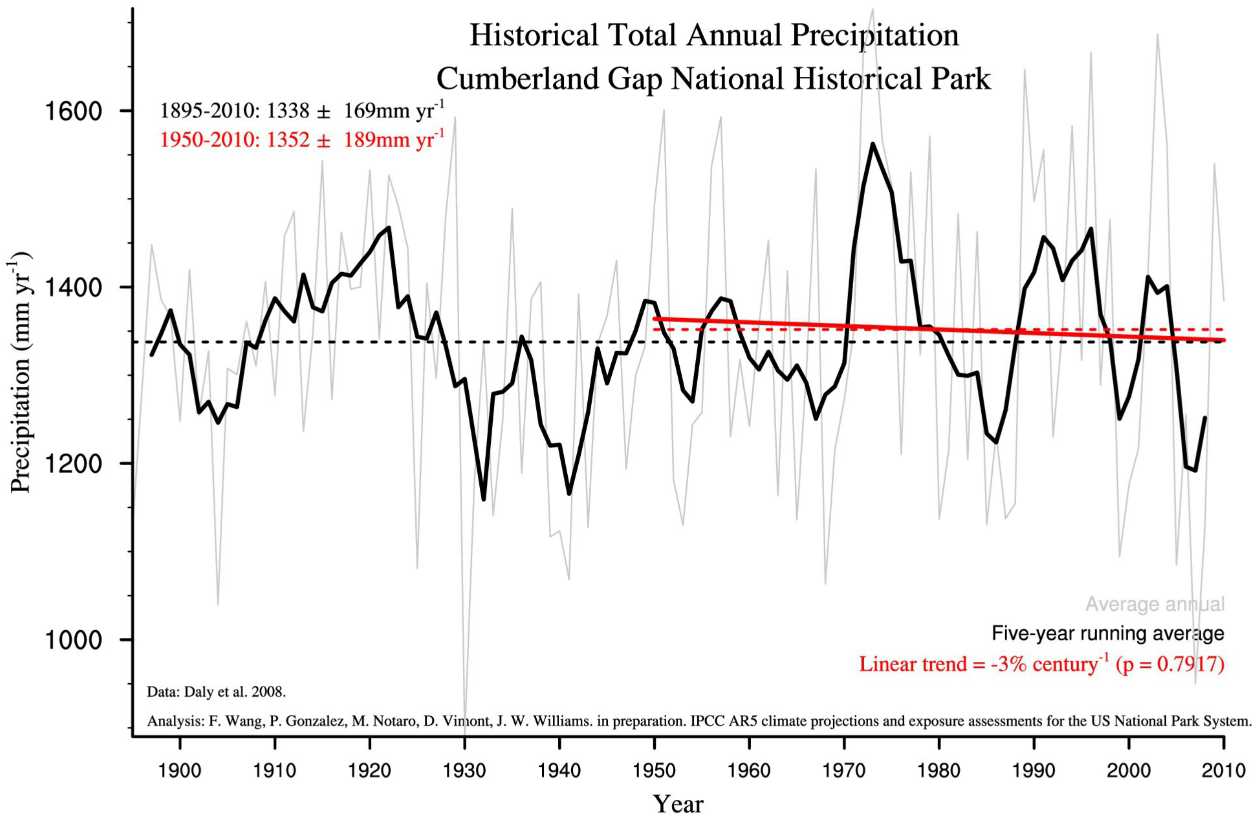
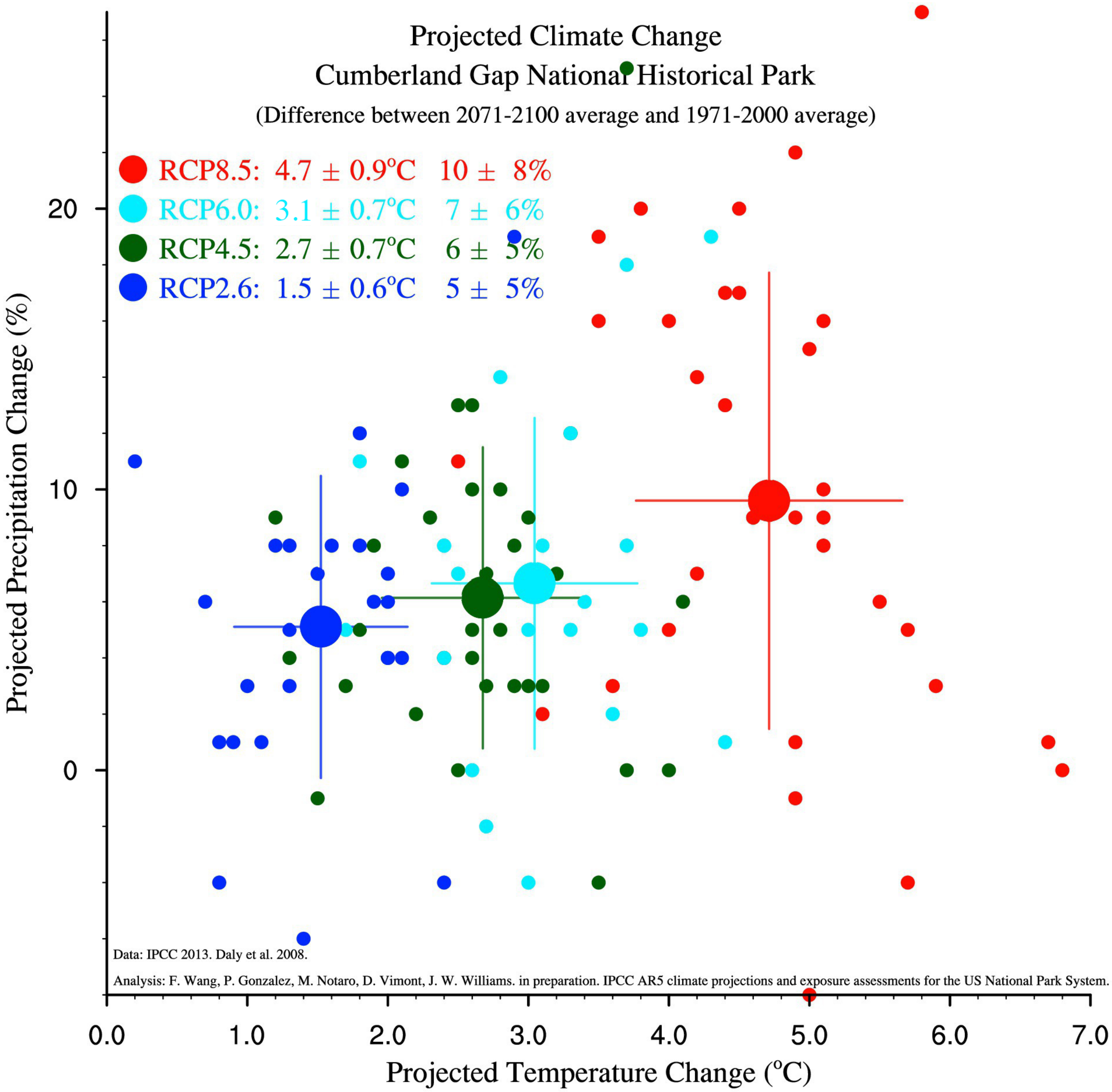


Figure 3. Projections of future climate for the area within park boundaries. Each small dot is the output of a single climate model. The large color dots are the average values for the four IPCC emissions scenarios. The lines are the standard deviations of each average value. (Data: IPCC 2013, Daly et al. 2008; Analysis: Wang et al. in preparation, University of Wisconsin and U.S. National Park Service).



References

Bradley, B.A., D.S. Wilcove, and M. Oppenheimer. 2010. Climate change increases risk of plant invasion in the Eastern United States. Biological Invasions 12: 1855-1872.

Daly, C., M. Halbleib, J.I. Smith, W.P. Gibson, M.K. Doggett, G.H. Taylor, J. Curtis, and P.P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. International Journal of Climatology 28: 2031-2064.

Dukes, J.S., J. Pontius, D. Orwig, J.R. Garnas, V.L. Rodgers, N. Brazee, B. Cooke, K.A. Theoharides, E.E. Stange, R. Harrington, J. Ehrenfeld, J. Gurevitch, M. Lerdau, K. Stinson, R. Wick, and M. Ayres. 2009. Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict? Canadian Journal of Forest Research 39: 231-248.

Intergovernmental Panel on Climate Change (IPCC). 2013. Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, UK.

Iverson, L.R., A.M. Prasad, S.N. Matthews, and M. Peters. 2008. Estimating potential habitat for 134 eastern US tree species under six climate scenarios. Forest Ecology and Management 254: 390-406.

La Sorte, F.A. and F.R. Thompson. 2007. Poleward shifts in winter ranges of North American birds. Ecology 88: 1803-1812.

Loeb, S.C and E.A. Winters. 2013. Indiana bat summer maternity distribution: effects of current and future climates. Ecology and Evolution 3: 103-114.

McNulty, S., P. Caldwell, T.W. Doyle, K. Johnsen, Y. Liu, J. Mohan, J. Prestemon, and G. Sun. 2013. Forests and climate change in the southeast USA. In K.T. Ingram, K. Dow, L. Carter, and J. Anderson. Climate of the Southeast United States. Island Press, Washington, DC.

Mohan, J.E., L.H. Ziska, W.H. Schlesinger, R.B. Thomas, R.C. Sicher, K. George, and J.S. Clark. 2006. Biomass and toxicity responses of poison ivy (*Toxicodendron radicans*) to elevated atmospheric CO_2. Proceedings of the National Academy of Sciences of the USA 103: 9086-9089.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, and J. Willis. 2014. Our changing climate. In Melillo, J.M., T.C. Richmond, and G. W. Yohe (Eds.) Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, Washington, DC.

Wang, F., P. Gonzalez, M. Notaro, D. Vimont, and J.W. Williams. in preparation. Significant historical and projected climate change in U.S. national parks.